DME
GERMAN DESALINATION

MENA Regional Water Outlook
Desalination Using CSP

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DME - Seminar

Desalination and Renewable Energies

May 4th – 5th, 2011

Berlin, Germany

MENA Regional Water Outlook

- Project supported by the World Bank
- In collaboration with Governments in the MENA Countries
- Objective: review of desalination potential in combination with renewable energies (CSP in particular) in the region as alternative water supply

THE WORLD BANK

FICHTNER

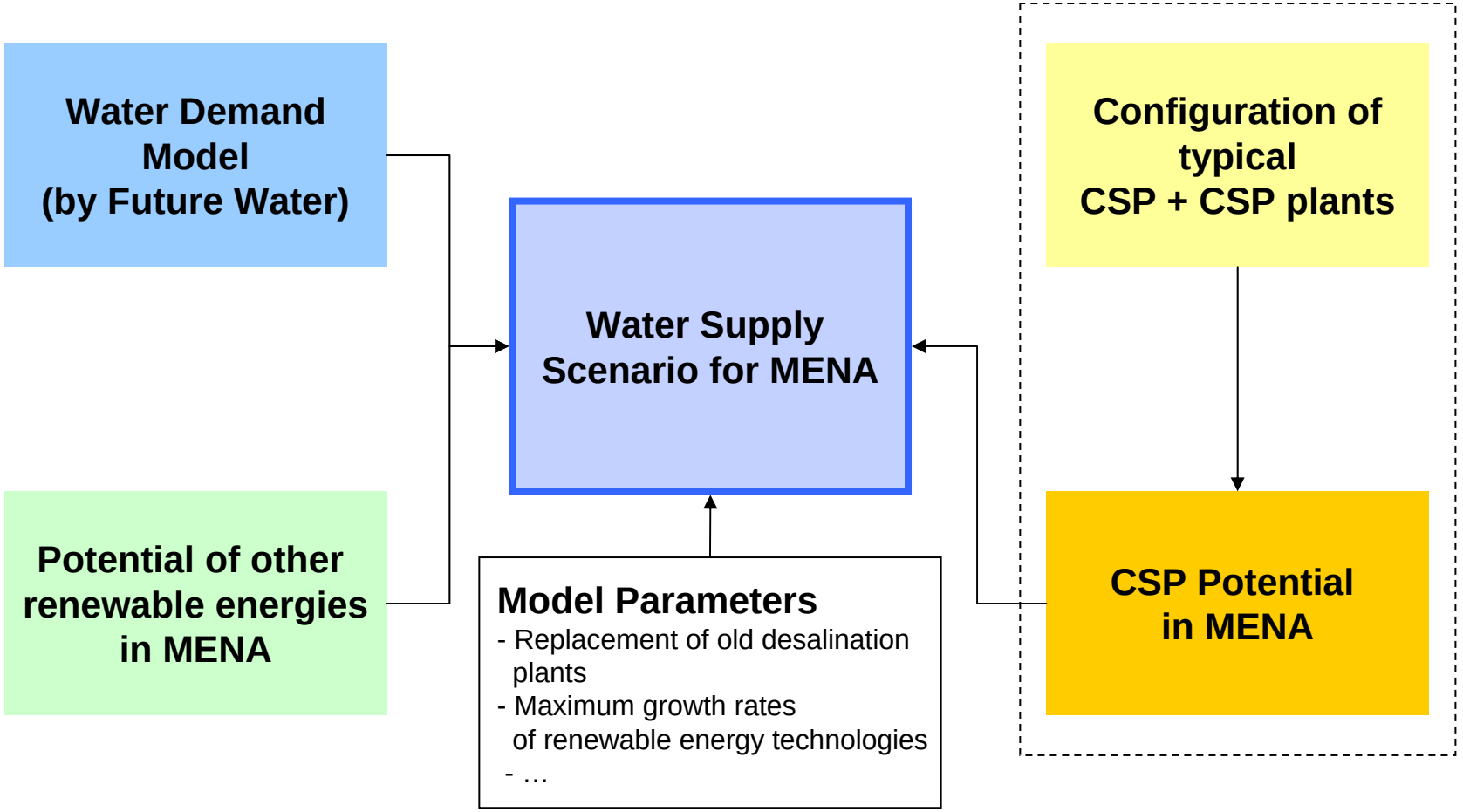
DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

Presentation overview

1. Applied Methodology
2. Typical CSP and Desalination Plants
3. CSP Potential Assessment
4. The Scope of CSP in the MENA Region
    - Electricity Supply Scenario
    - Water Supply Scenario

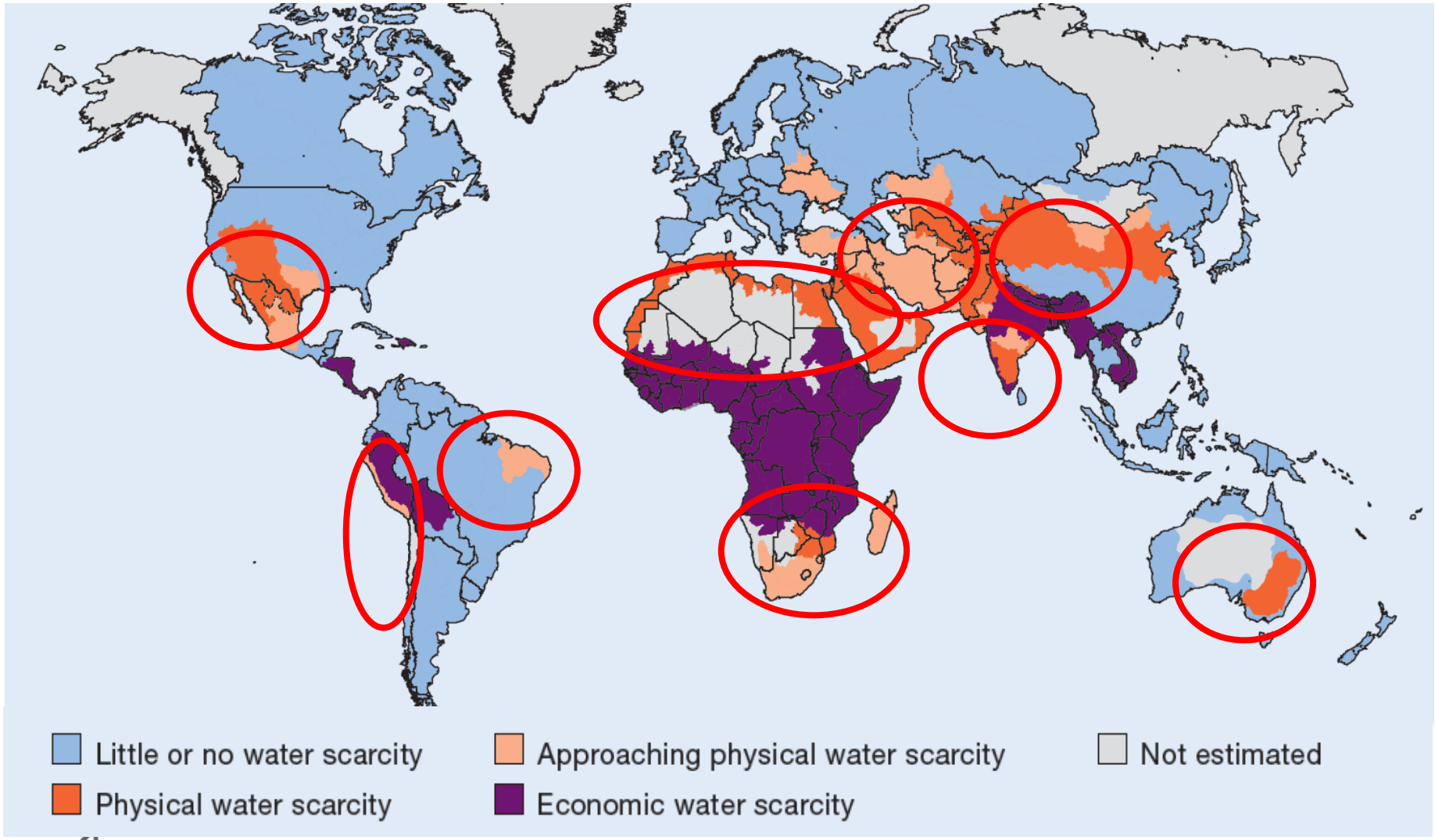
Methodology

Water Supply Scenario



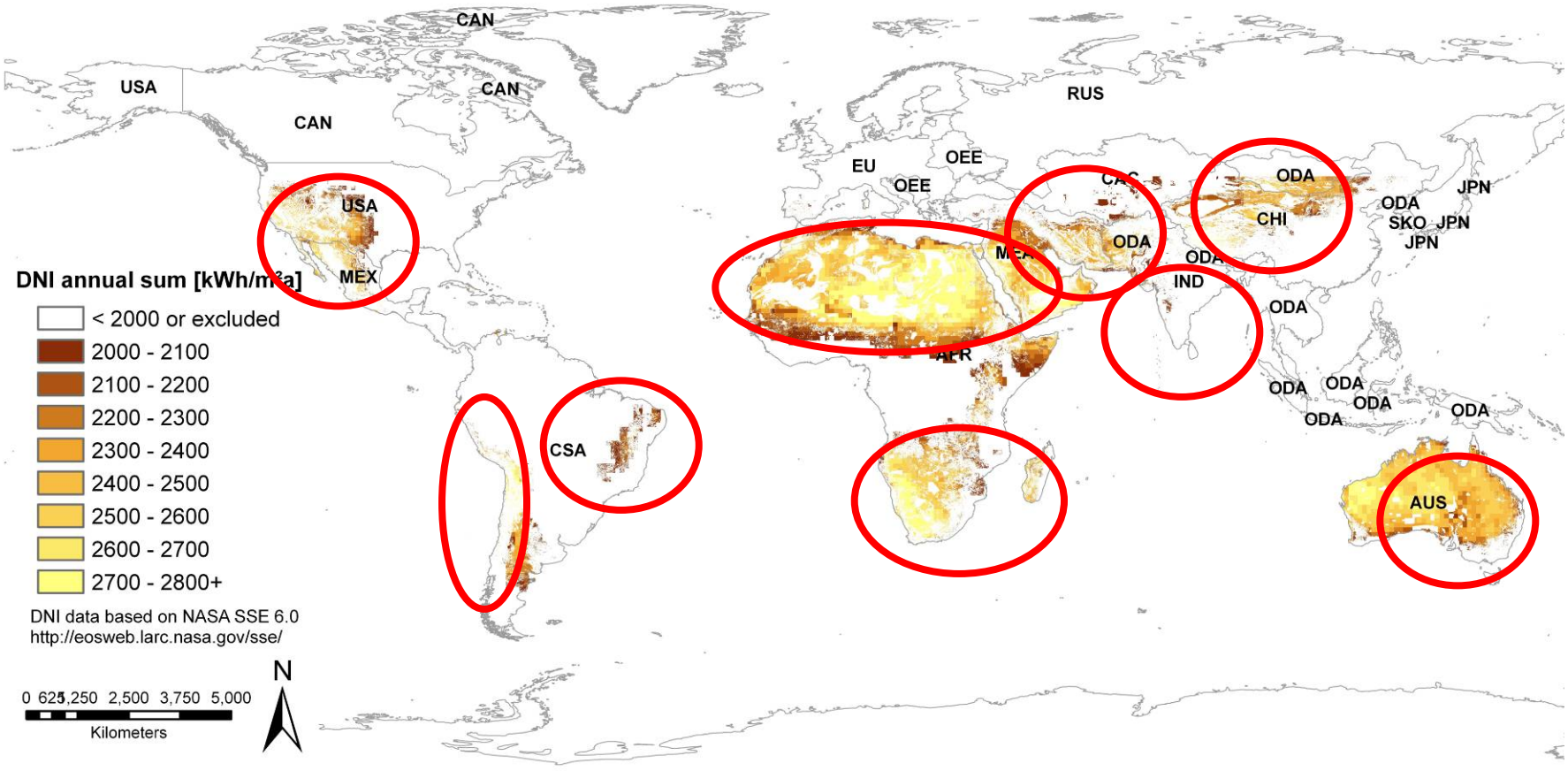
CSP Technology Overview

Global Water Scarcity



Source: IWMI 2006

Global Potential for Concentrating Solar Power



Data provided by DLR (2008) for EU-project REACCESS

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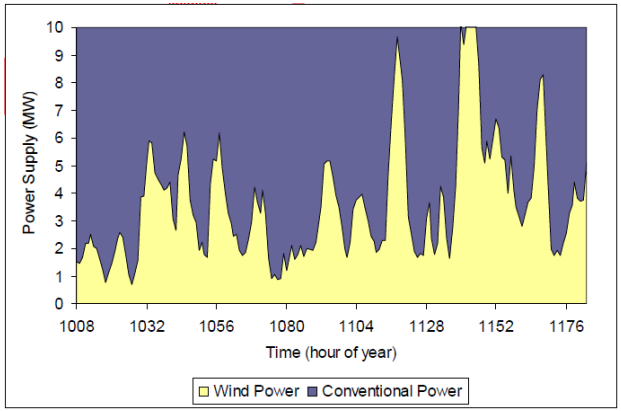
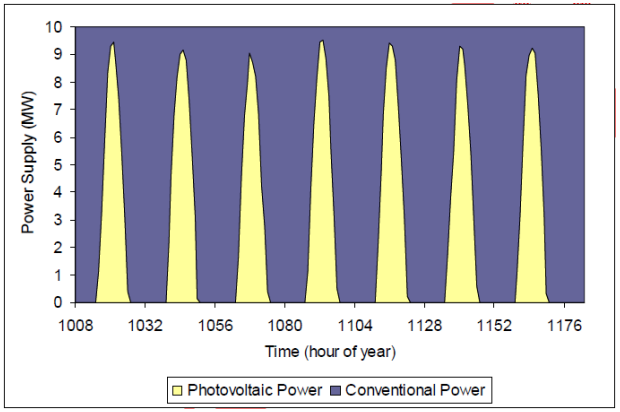
Source: REACCESS 2009

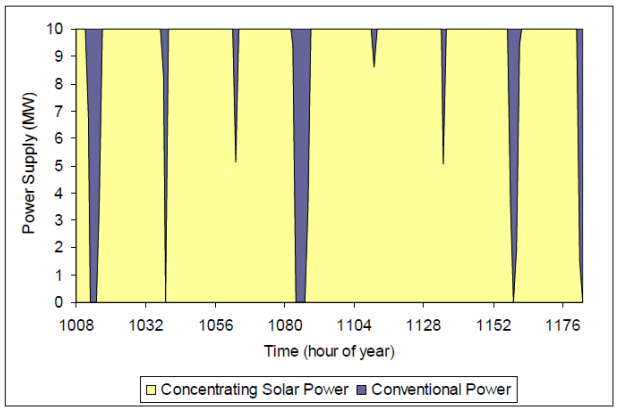
Renewable energies for desalination: why CSP?



Wind Power



Photovoltaic



CSP

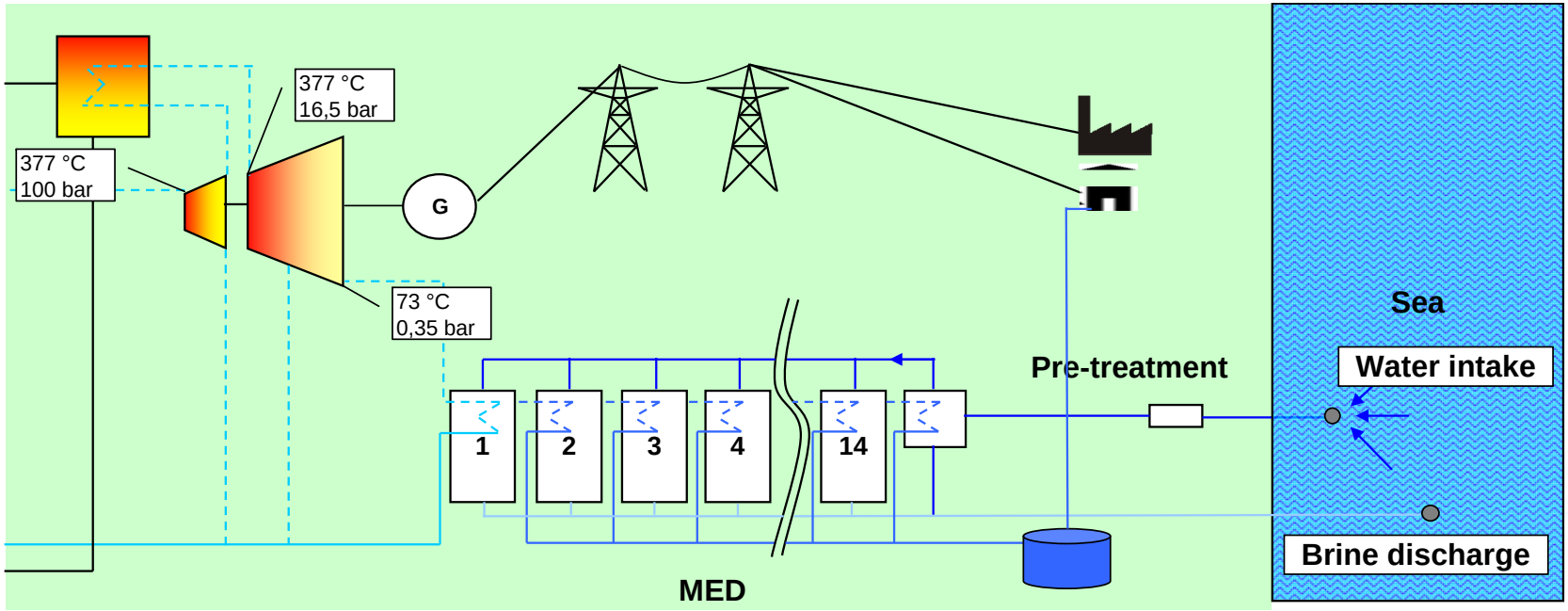
Desalination plants require continuous operation

→ This conflicts with the intermittent nature of renewable energies
→ Storage of electricity is expensive
→ CSP offers the option of thermal energy storage
→ Hybrid operation is possible in the same power block (no “shadow power plant” required)

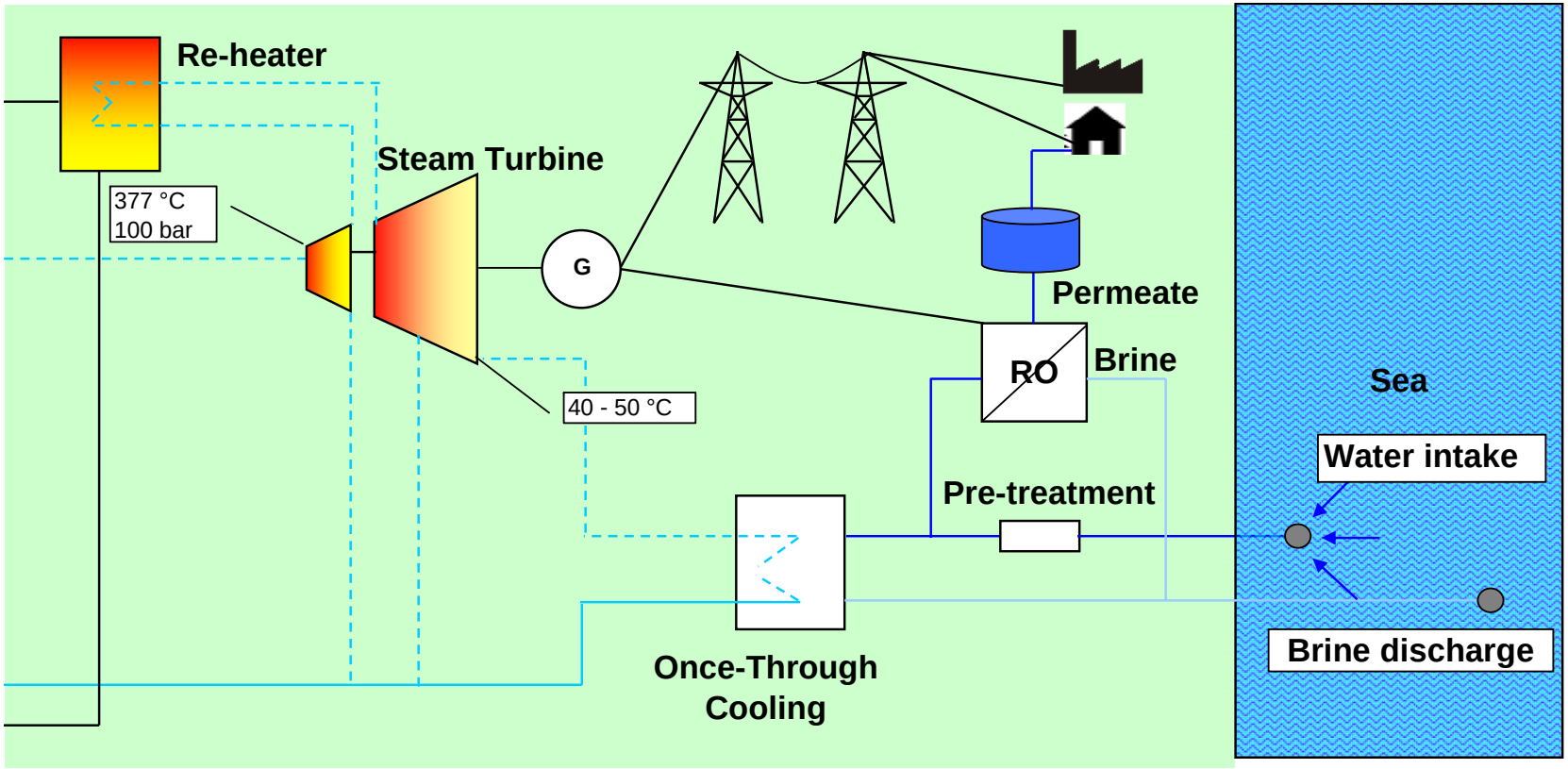
Analyzed Configurations

Desalination	100,000 m^3/day
Gross Power	110 – 120 MW
Operation	Base load (8,000 hours/y)
Thermal Storage	SM 2 (7.5 hours full load operation)
Locations	1) Mediterranean Sea / Atlantic Ocean 2) Red Sea / Indian Ocean 3) Arabian Gulf
Configurations	1) CSP+MED (coast site) 2) CSP/once-through-cooling + RO (coast site) 3) CSP/dry-cooling (inland site) + RO 4) CSP/dry-cooling/solar-only (inland) + RO (back-up from grid)
DNI	1) 2,000 kWh/m^2/year coast site + 2,400 kWh/m^2/year inland site 2) 2,400 kWh/m^2/year coast site + 2,800 kWh/m^2/year inland site

CSP - MED

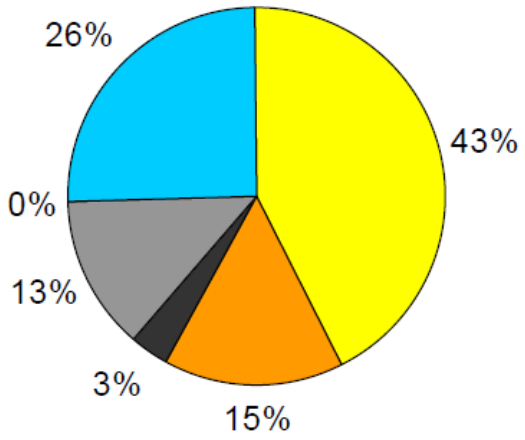

377 °C
16,5 bar
377 °C
100 bar
G
73 °C
0,35 bar
1
2
3
4
14
MED
Pre-treatment
Sea
Water intake
Brine discharge

CSP coast - RO


Re-heater
377 °C
100 bar
Steam Turbine
G
Permeate
RO
Brine
40 - 50 °C
Sea
Water intake
Pre-treatment
Brine discharge
Once-Through
Cooling

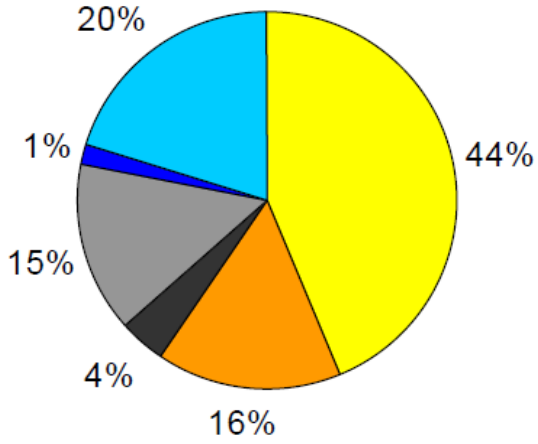
Investment Cost

CSP/MED

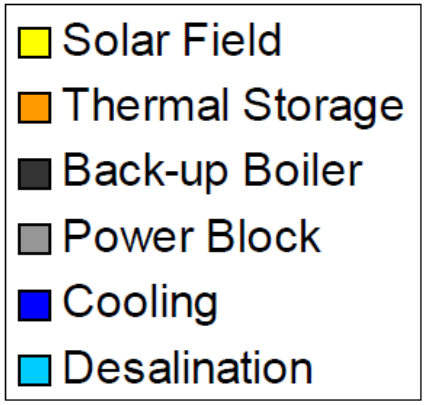


Σ = 651.8 Mio. €

CSP/once-through-cooling/RO

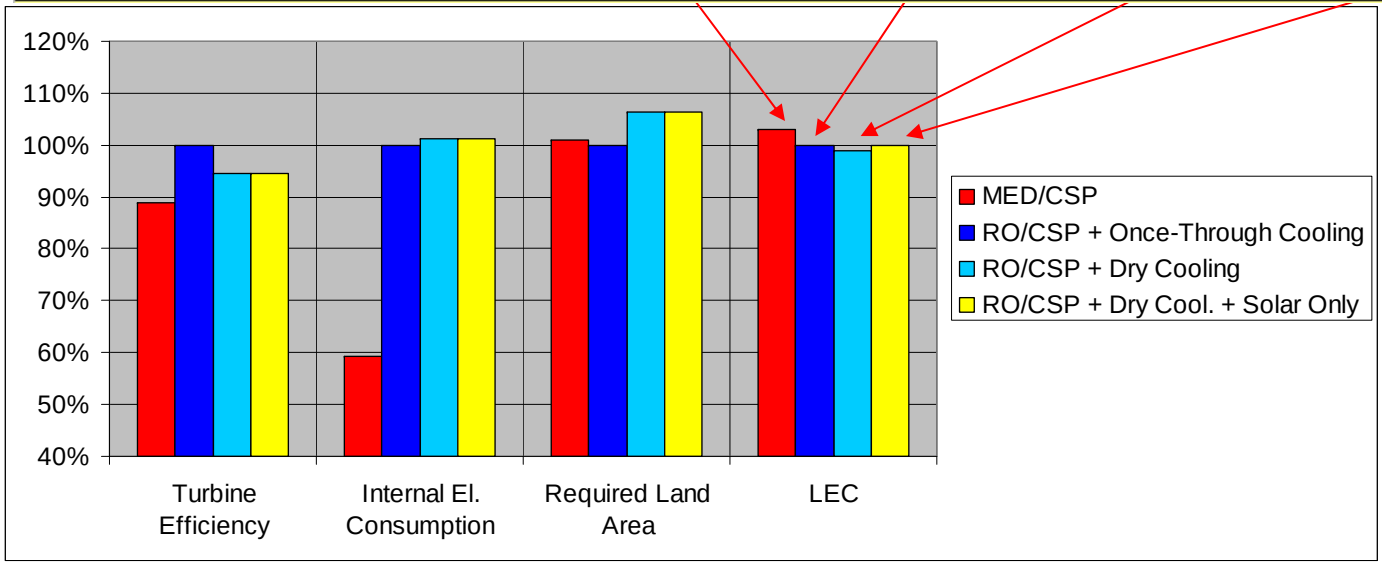


Σ = 672.5 Mio. €



Comparison of Configurations

	Unit	CSP/MED	CSP/RO + Once-Through Cooling	CSP/RO + Dry Cooling	CSP/RO + Dry Cooling + Solar Only
Gross Turbine Efficiency	%	32.9	37.0	35.0	
Gross Power Production	MW	107.8	120.0	120.4	
Internal Power Consumption	MW	17.8	30.0	30.4	
Mirror area	km^2	1.26	1.25	1.32	
Land use	km^2	4.78	4.73	5.03	
Solar Full Load Hours	h/year	3,652		4,344	
Total Full Load Hours	h/year	8,000			4,344
Solar Share	%	45.7%		54.3%	100.0%
Total Net Power Production	GWh el/year	719.8			390.8
Total Water Production	Mio. m^3/year	33.3			
LEC	US$cent/kWh	22.03	21.40	21.19	21.37

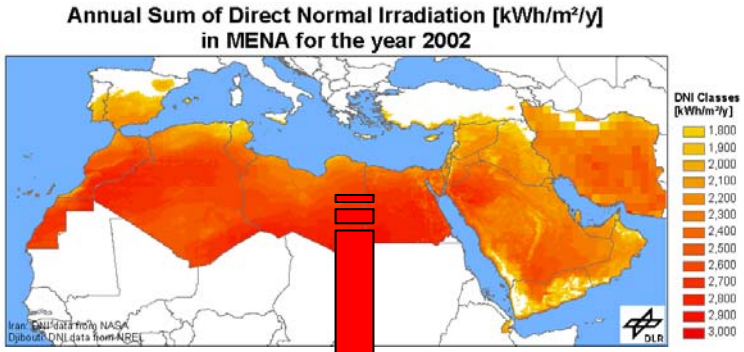


Assumptions: Location: Arabian Gulf; DNI: 2,400 kWh/m²/y; Fuel: HFO

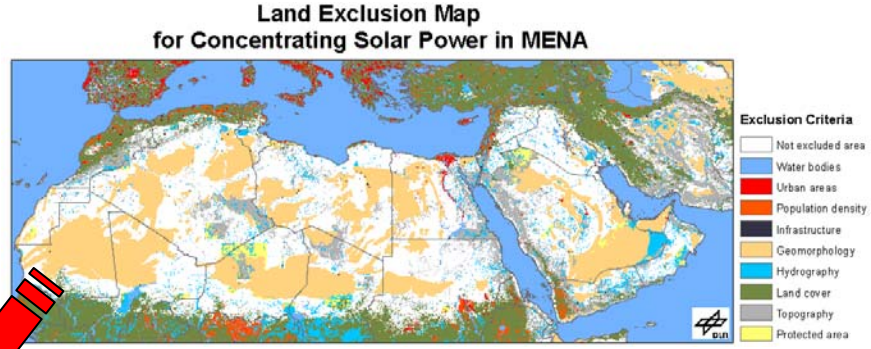
CSP Potential in MENA

Methodology:

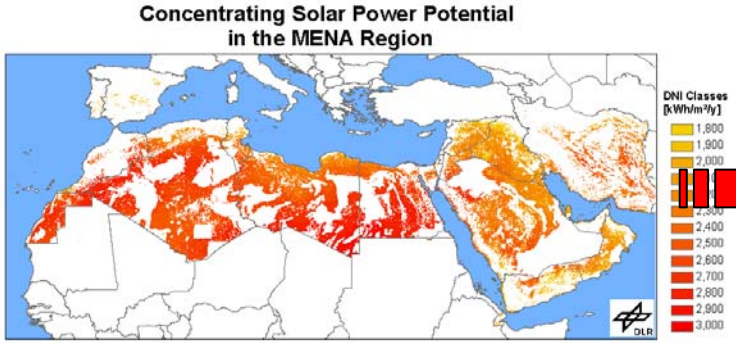
I. Solar Resource Assessment



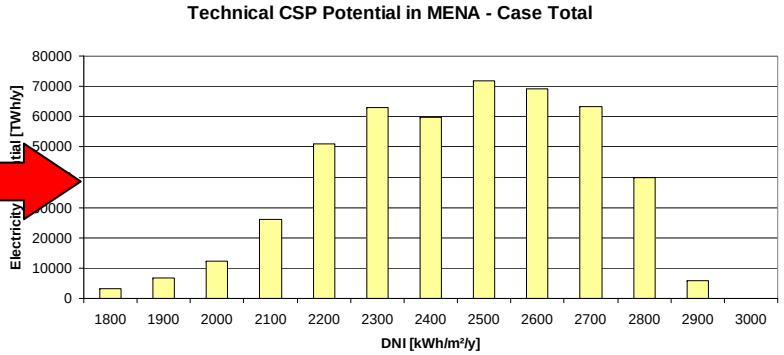
II. Land Resource Assessment



III. CSP Potential



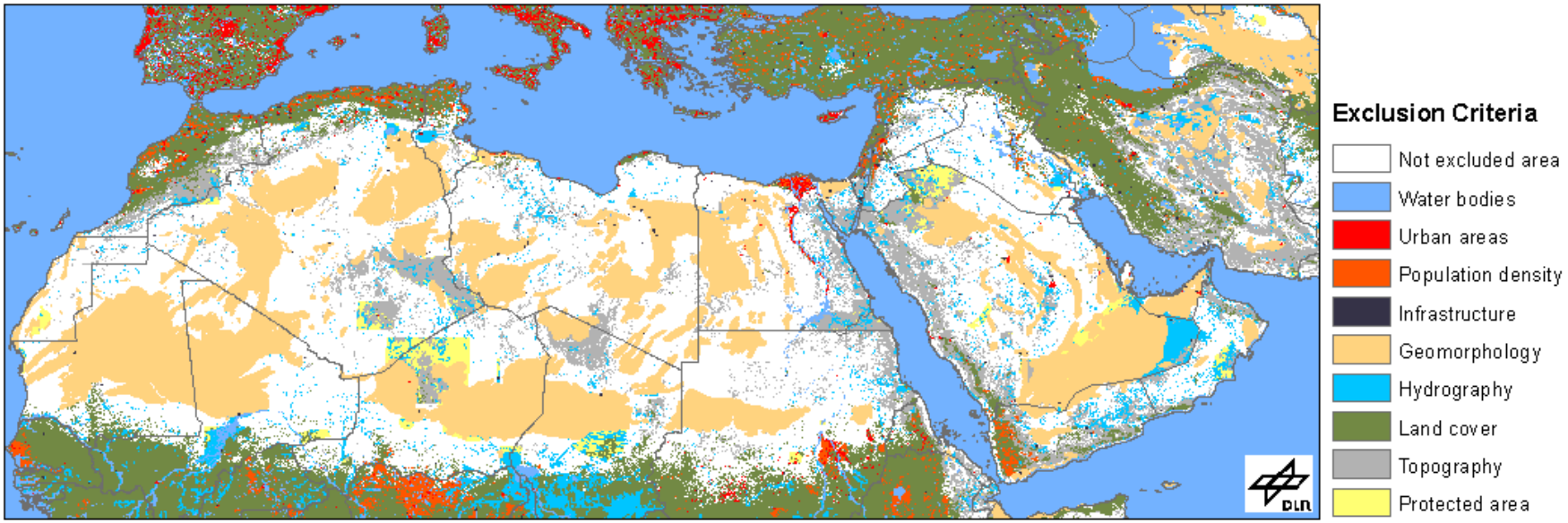
IV. Statistical Evaluation



CSP Potential in MENA

Land Resource Assessment:

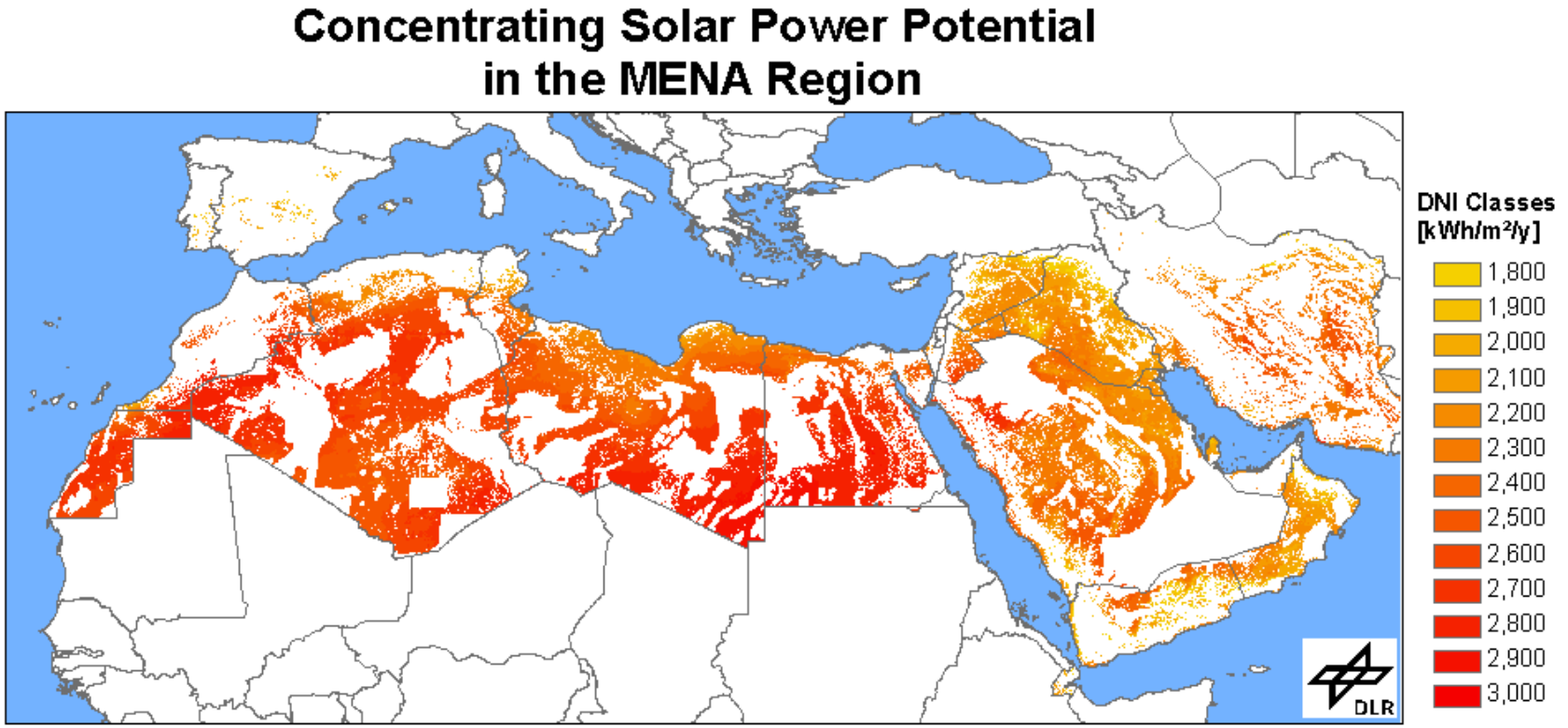
Land Exclusion Map
for Concentrating Solar Power in MENA



CSP Potential in MENA

CSP Potential Map

- Combining data from solar resource assessment and land resource assessment
- Results: Annual sum of DNI on areas which are suitable for CSP power plants



CSP Potential in MENA

Input for Electricity and Water Supply Scenarios

- CSP potential for electricity generation of each MENA country

	Total		Coast	
	Technical Potential [TWh/y]	Economical Potential [TWh/y]	Technical Potential [TWh/y]	Economical Potential [TWh/y]
	[DNI > 1800 kWh/m²/y]	[DNI > 2000 kWh/m²/y]	[DNI > 1800 kWh/m²/y]	[DNI > 2000 kWh/m²/y]
Algeria	135823	135771	0.3	0
Bahrain	16	16	9	9
Djibouti*	372	300	0	0
Egypt	57143	57140	74	74
Gaza Strip & Westbanks	8	8	0	0
Iran*	32597	32134	267	267
Iraq	27719	24657	0	0
Israel	151	151	2	2
Jordan	5885	5884	0	0
Kuwait	1372	1372	18	18
Lebanon	5	5	0	0
Libya	82727	82714	135	132
Malta	0	0	0	0
Morocco	8463	8428	15	15
Oman	15460	14174	84	84
Qatar	696	555	56	43
Saudi Arabia	76318	75832	152	152
Syria	9616	8449	1	1
Tunisia	5762	5673	58	49
United Arab Emirates	493	447	15	15
Yemen	11432	8486	108	104
Total	**472057**	**462196**	**995**	**964**

Power Scenario Methodology

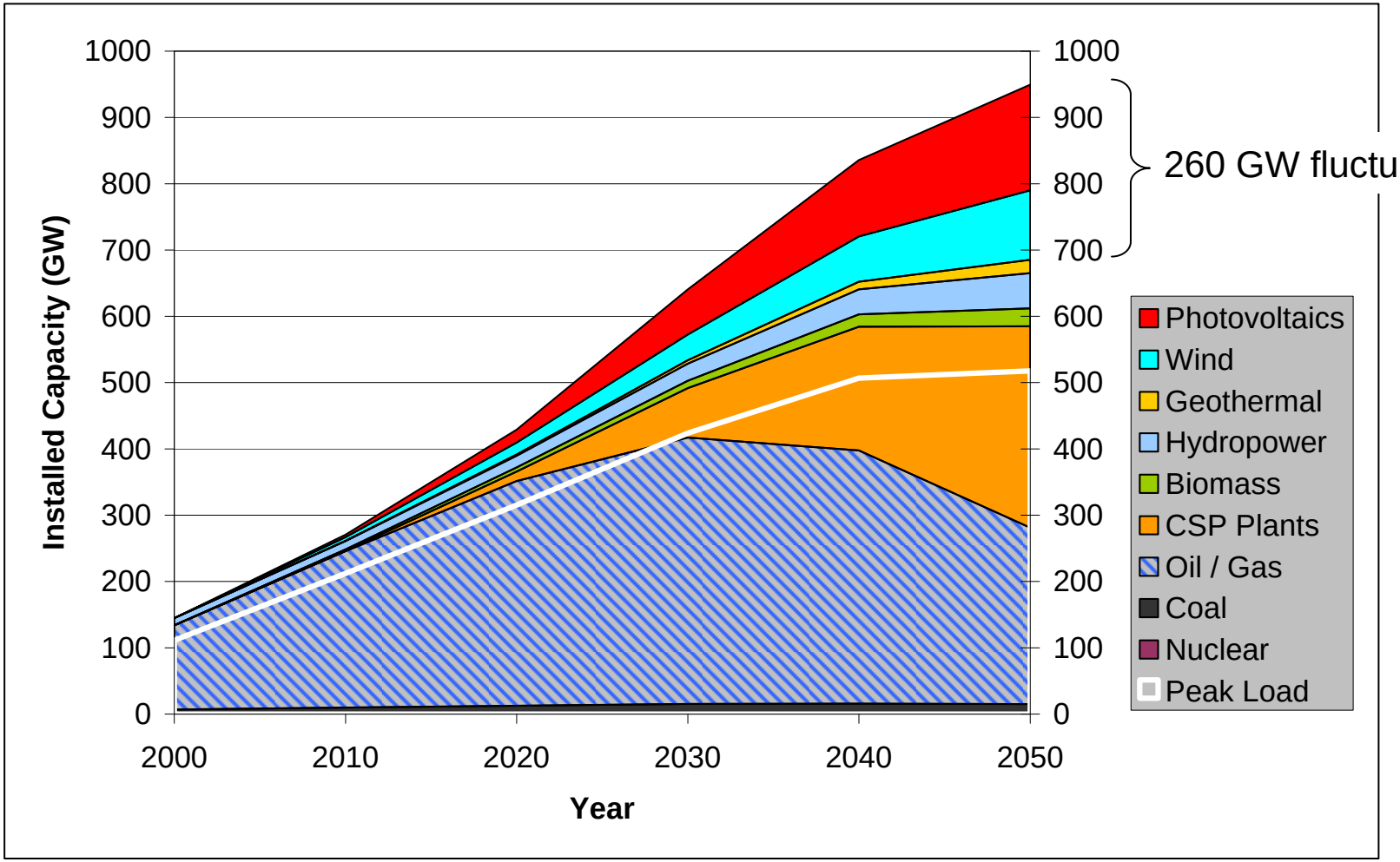
1. power demand from 2000 to 2050
2. economic renewable energy potential for power generation
3. life cycle of old power plants opens opportunity for replacement
4. share of power technologies on firm capacity ➔ 125% availability
5. performance (load factor) of each technology
6. sustainable: secure, inexpensive, compatible
7. well balanced mix of fluctuating and storable sources
8. no technical break through required

Renewable Power Generation Potential by Sources in TWh/y

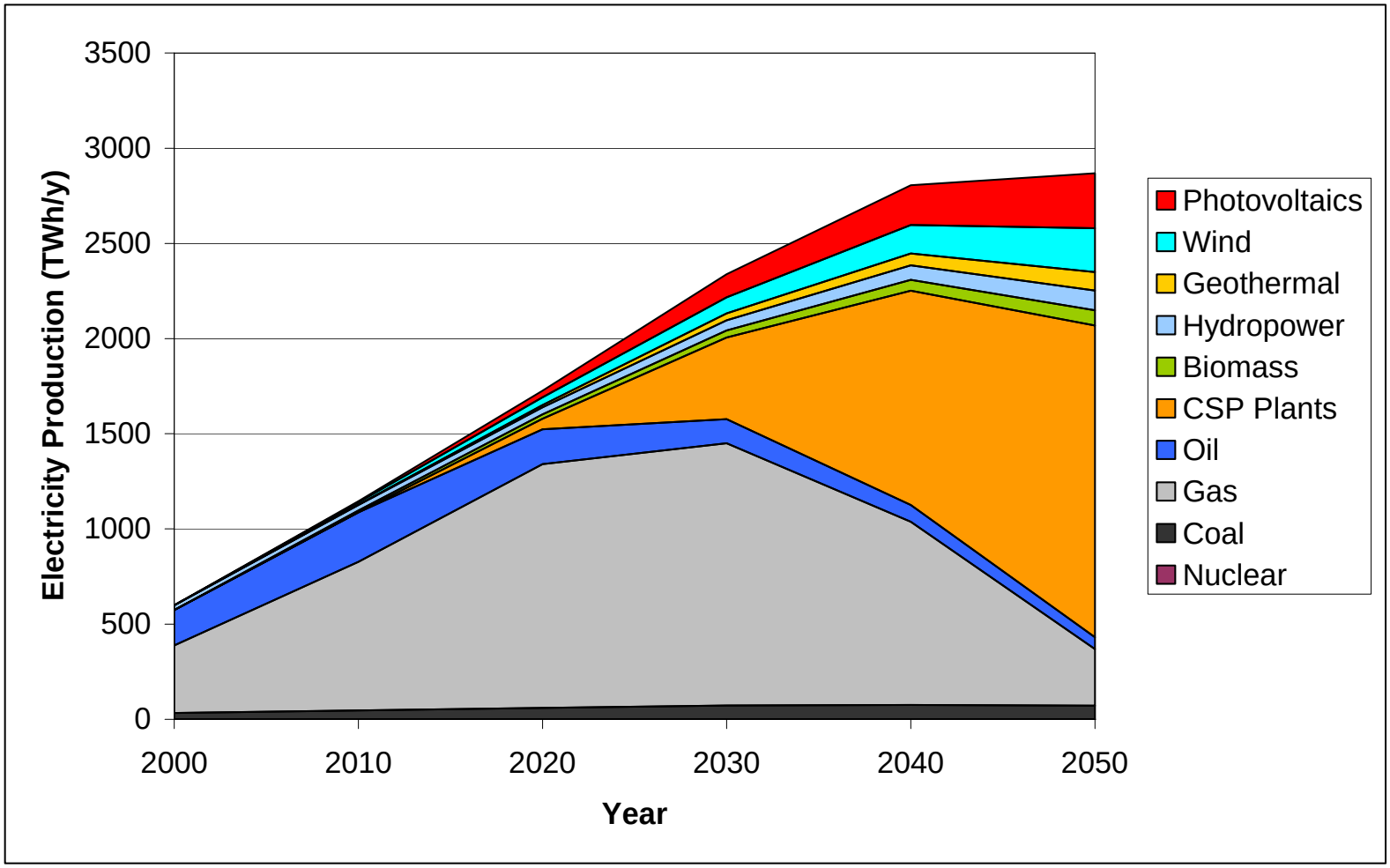
	Hydro	Geo	Bio	CSP	Wind	PV *
Algeria	0.5	4.7	12.3	135771	35.0	20.9
Bahrain	0.0	0.0	0.2	16	0.1	0.5
Djibouti	0.0	0.0	0.0	300	1.0	50.0
Egypt	50.0	25.7	14.1	57140	125.0	54.0
Gaza & WB	0.0	0.0	1.7	8	0.5	20.0
Iran	48.0	11.3	23.7	32134	12.0	54.0
Iraq	67.0	0.0	8.8	24657	20.0	34.6
Israel	7.0	0.0	2.3	151	0.5	6.0
Jordan	0.1	0.0	1.6	5884	5.0	6.7
Kuwait	0.0	0.0	0.8	1372	n.a.	3.8
Lebanon	1.0	0.0	0.9	5	1.0	5.0
Libya	0.0	0.0	1.8	82714	15.0	7.8
Malta	0.0	0.0	0.1	0	0.2	0.2
Morocco	4.0	10.0	14.3	8428	35.0	17.0
Oman	0.0	0.0	1.1	14174	8.0	4.1
Qatar	0.0	0.0	0.2	555	n.a.	1.5
Saudi Arabia	0.0	70.9	10.0	75832	20.0	20.8
Syria	4.0	0.0	4.7	8449	15.0	17.3
Tunisia	0.5	3.2	3.2	5673	8.0	3.7
UAE	0.0	0.0	0.7	447	n.a.	9.0
Yemen	0.0	107.0	9.1	8486	3.0	19.3
Total	**182**	**233**	**111**	**462196**	**304**	**356**

Source: www.dlr.de/tt/med-csp

Installed Capacity in all MENA Countries by Sources



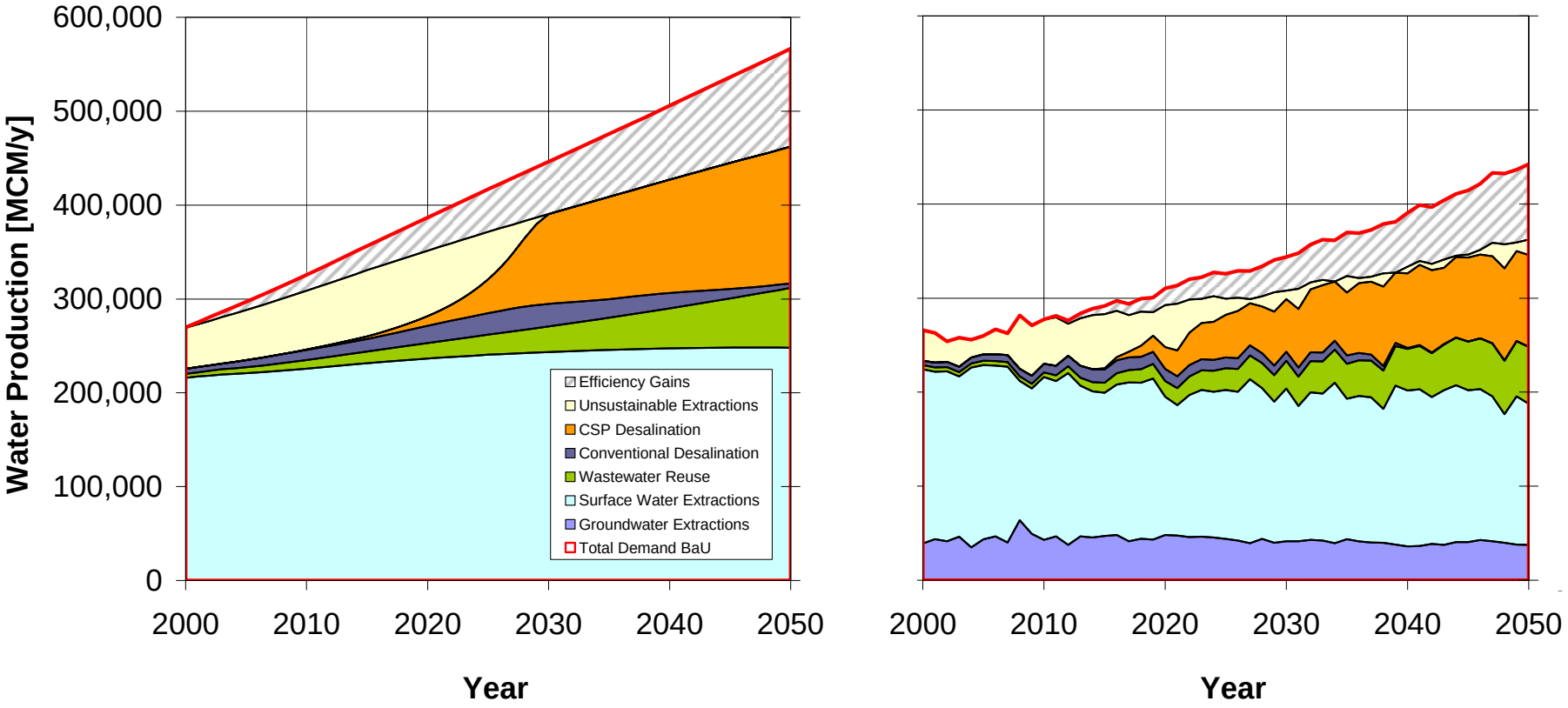
Electricity Production of all MENA Countries by Sources



Water Scenario Methodology

1. water demand from 2000 to 2050
2. total and coastal CSP potential for desalination
3. life cycle of old desal plants opens opportunity for replacement
4. top priority for efficiency gains
5. second priority for reuse of waste water
6. third priority for sustainable surface and ground water extractions
7. fourth priority for existing and planned conventional desal plants
8. last priority for CSP desalination after 2015
9. no priority for unsustainable water extractions

AQUA-CSP Scenario vs. MENA Water Outlook

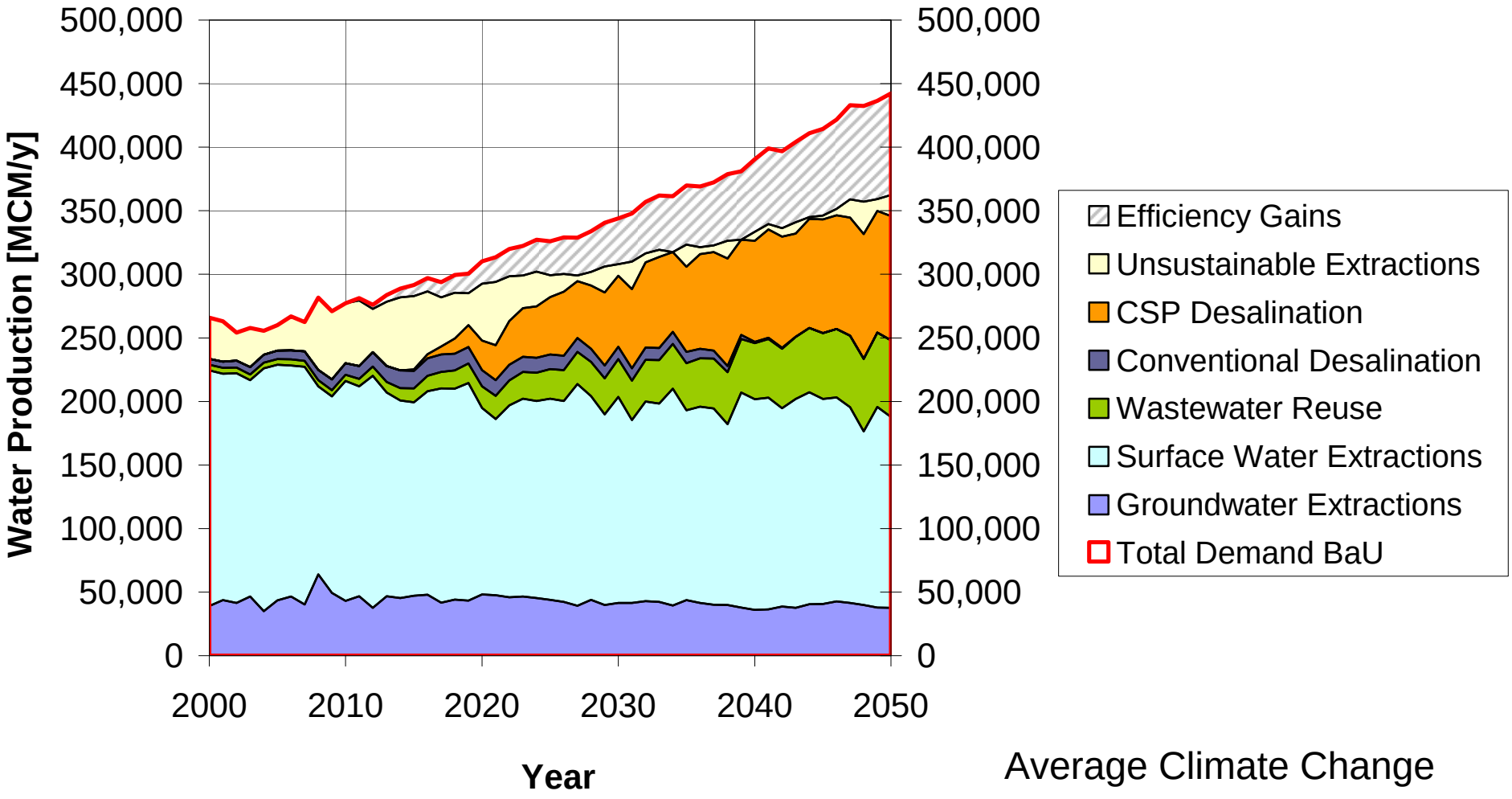


constant reduced

per capita water for irrigation

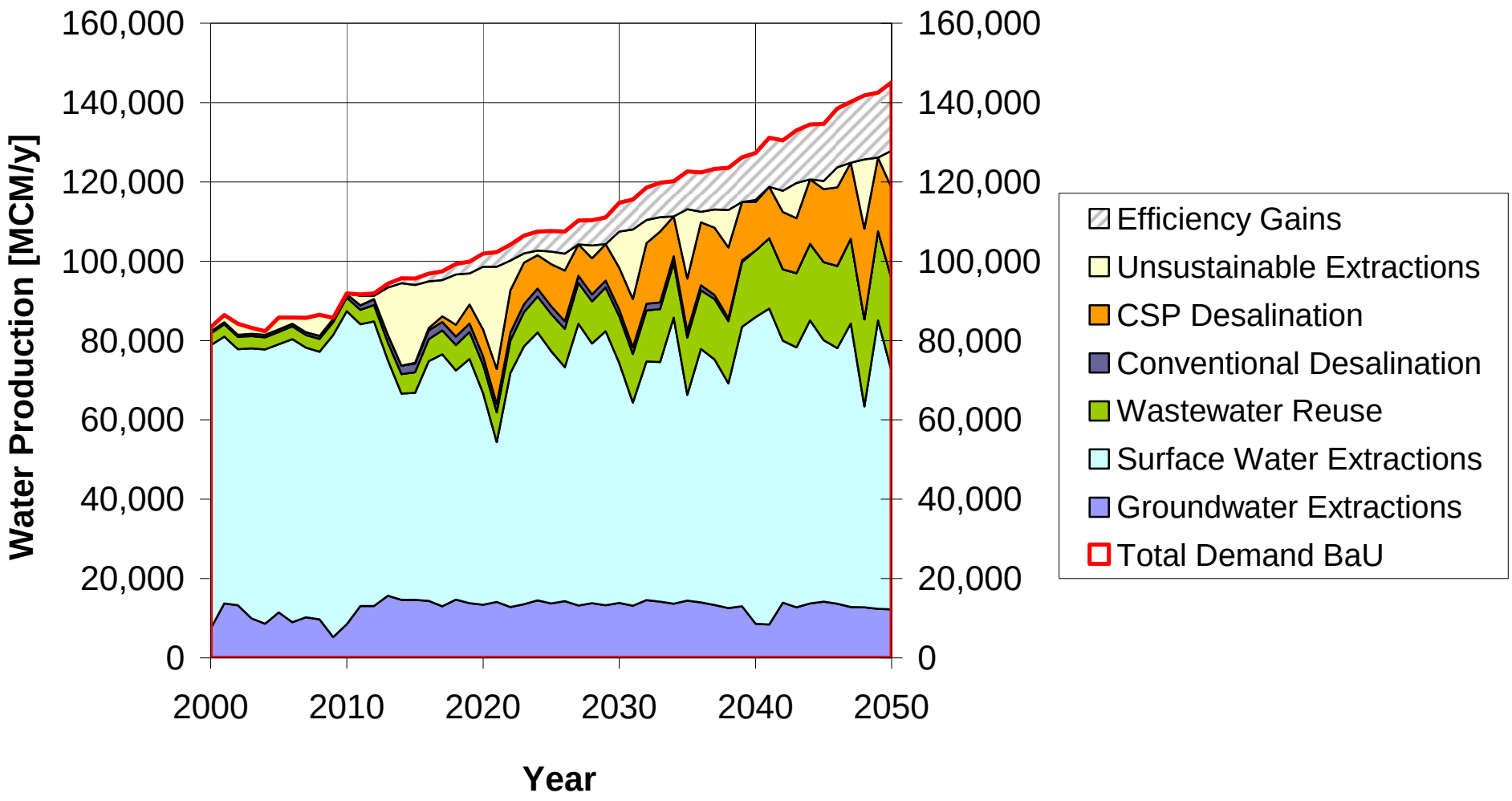
Source: www.dlr.de/tt/aqua-csp

Middle East & North Africa (MENA)

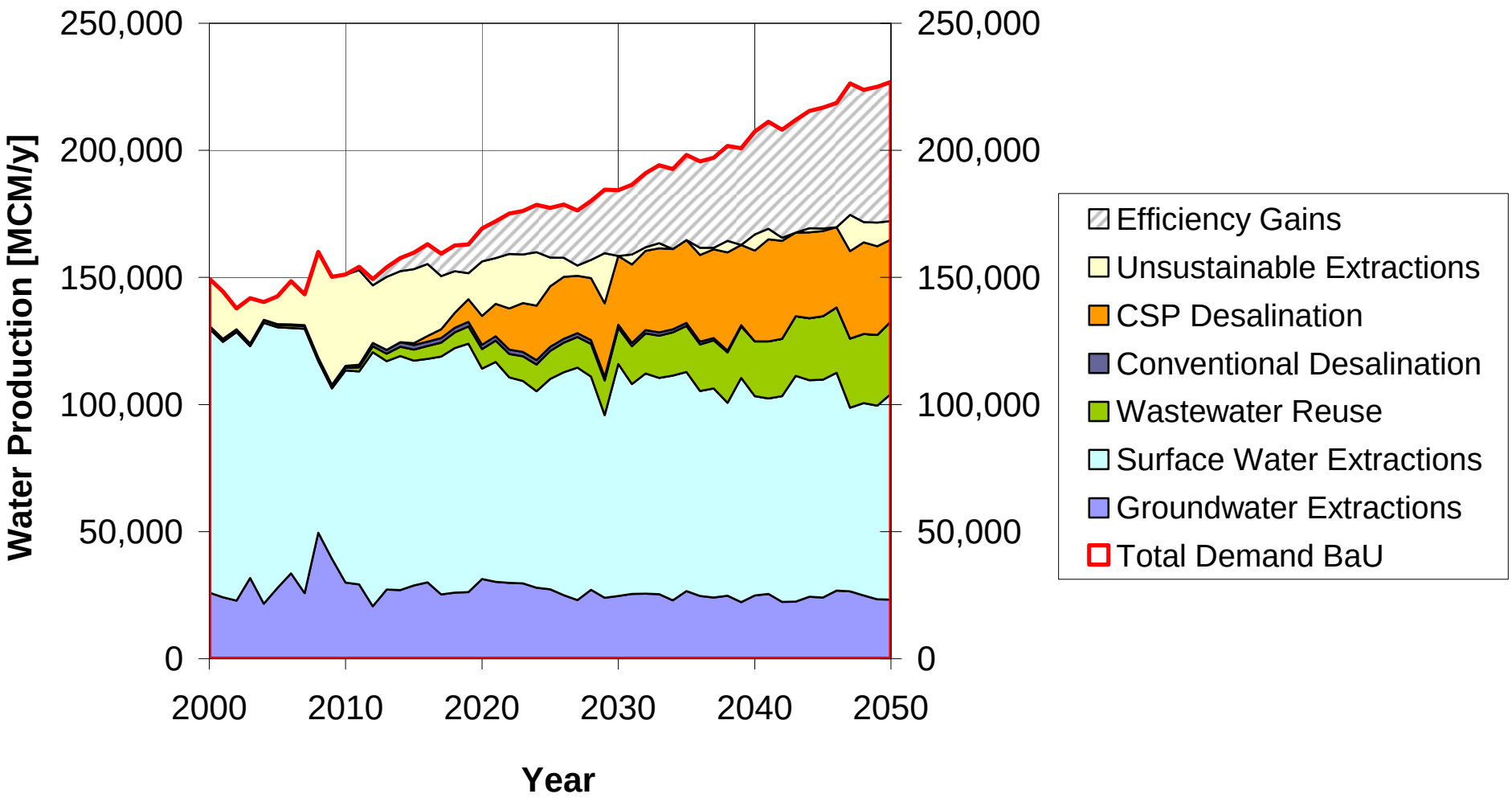


Average Climate Change

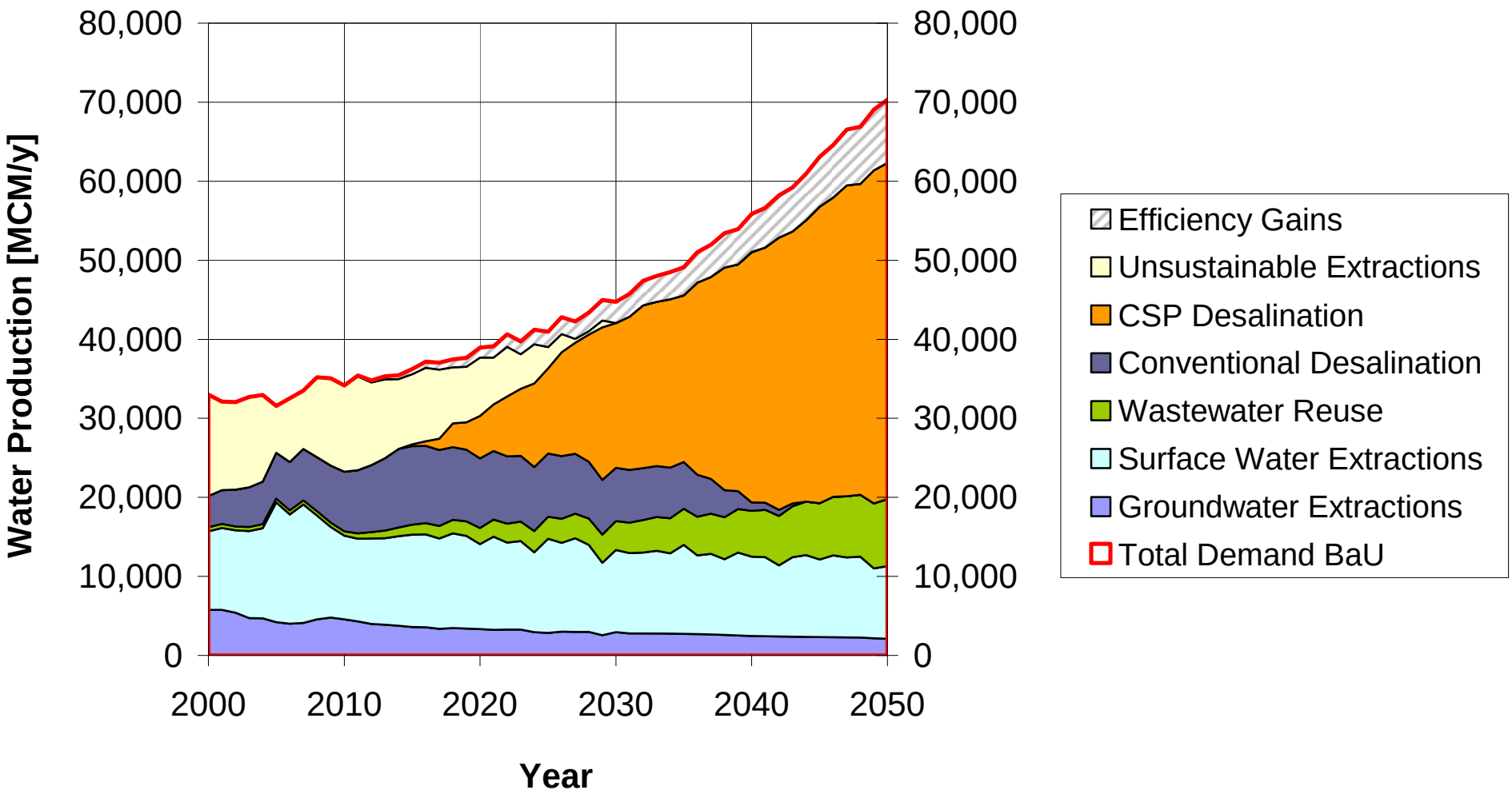
North Africa

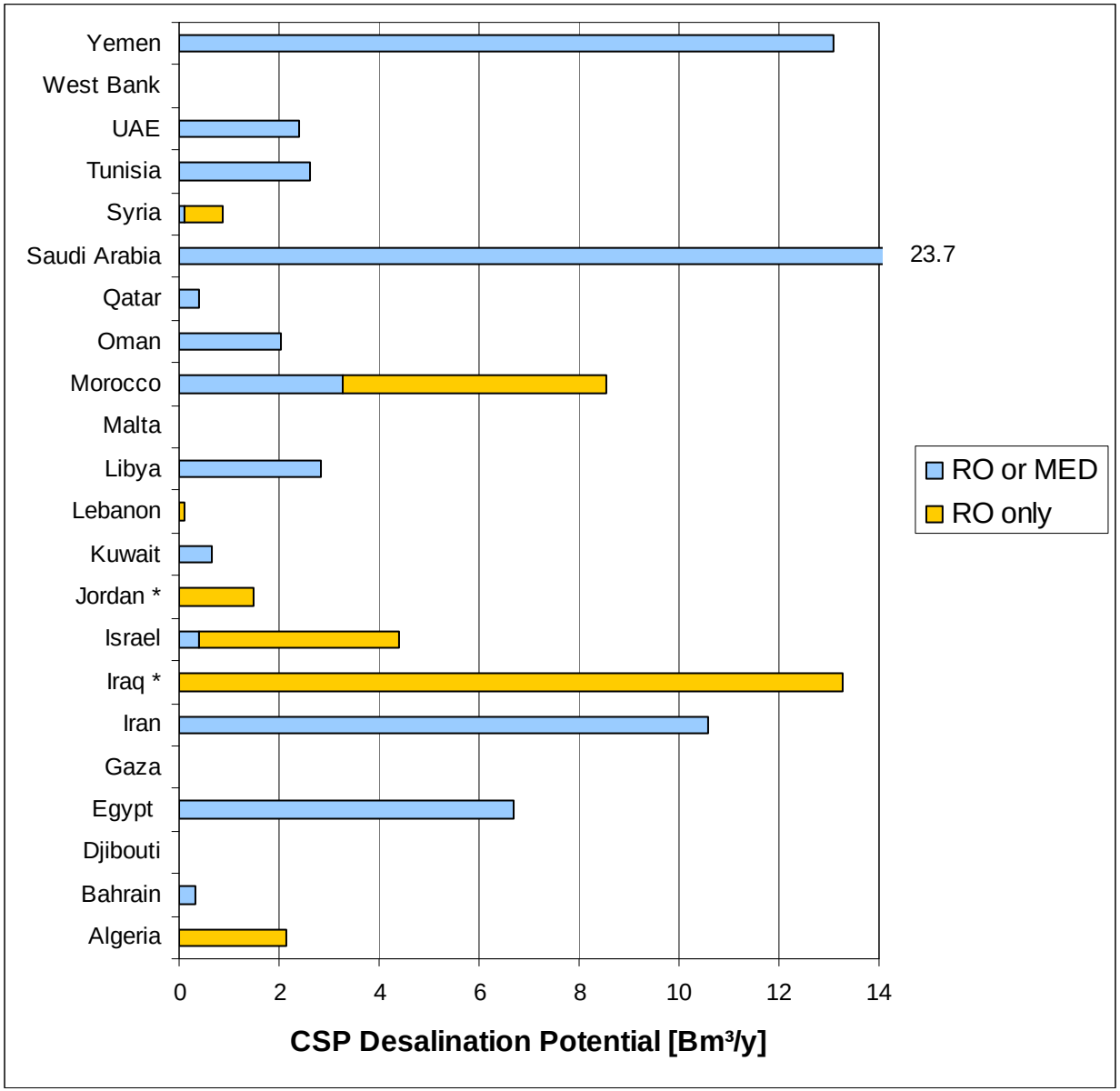


Western Asia



Arabian Peninsula




Yemen
West Bank
UAE
Tunisia
Syria
Saudi Arabia
Qatar
Oman
Morocco
Malta
Libya
Lebanon
Kuwait
Jordan *
Israel
Iraq *
Iran
Gaza
Egypt
Djibouti
Bahrain
Algeria
23.7
0
2
4
6
8
10
12
14
RO or MED
RO only
CSP Desalination Potential [Bm³/y]

Why CSP for Water in MENA?

1. CSP potential is very large even at coastal sites
2. good seasonal correlation of availability and demand
3. most abundant in regions with highest water scarcity
4. base load for uninterrupted operation of desalination plants
5. solar powered pre-treatment replaces chemicals

Thank You!